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ABSTRACT

A project investigated the feasibility of developing equipment simulations in vocational curricula using videotapes and microcomputers. To conduct the research, two pieces of equipment that could be used in vocational curricula throughout the North Carolina Community College System were chosen: (1) computer numerical control (CNC) lathe used in machine shops and similar operations and (2) electronic fuel injection (EFI) systems. Two computer-assisted instruction (CAI) packages for use in vocational curricula were developed. A program on EFI systems for use in automotive mechanics consisted of two computer diskettes containing a tutorial, graphics simulations, and a recordkeeping system. A program on CNC equipment for use in machine shop curricula included a similar computer package and a videotape segment on the CNC work environment. An instructor's guide accompanied each package. The programs were produced on an Apple IIe microcomputer. A final report and slide/tape presentation on the project were produced. These benefits of CAI were found: lower equipment and materials costs, increased safety, overcoming of problems involved in group demonstrations, and self-pacing. Other conclusions were that initial development of CAI is time consuming and costly, but benefits can be shared and faculty need release time. (Instructor's guides and project materials are appended.) (YLB)

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FINAL REPORT

DEVELOPMENT OF MICROCOMPUTER SIMULATIONS FOR VOCATIONAL/TECHNICAL EDUCATION

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June, 1985

A Project Funded by
Occupational Education Research Services
Division of Planning and Research Services
North Carolina Department of Community Colleges
Raleigh, NC 27611

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NORTH CAROLINA DEPARTMENT OF COMMUNITY COLLEGES
DIVISION OF PLANNING AND RESEARCH SERVICES
OCCUPATIONAL EDUCATION RESEARCH SERVICES
RALEIGH, NC 27611

RESEARCH PRIORITY AREA: Institutional Nontraditional Educational Delivery

PROJECT TITLE: Development of Microcomputer Simulations for Vocational/Technical Education

.To research the feasibility of developing educational resource materials, consisting of videotapes and microcomputer software, to provide vocational students with exposure to equipment which may be prohibitively expensive for purchase by all vocational programs within the Community College System.

PROJECT DATES: Beginning: November 1, 1983
Ending: February 28, 1985
Duration: 16 months

BUDGET: $29,893

AGENCY: Randolph Technical College
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ABSTRACT

Problem

Vocational training programs in all 58 of the institutions in the North Carolina Community College System rely heavily on "hands-on" experience to prepare students for employment. This experience should provide students with exposure to state-of-the-art equipment such as that used in industry. Employers expect graduates to require minimal additional training on specific types of equipment.

Rapid technological advances and change in business and industry have made it increasingly difficult in recent years for the institutions in the Community College System to remain current in their vocational/technical curricula. The introduction of computerized systems in almost all areas of occupational training has resulted in the need for major upgrading of many of the System's vocational training programs. The new equipment required for such an undertaking has frequently been prohibitively expensive for many of the System's institutions.

Purpose and Objectives of Project

The primary purpose of this project was to research the feasibility of developing equipment simulations utilizing videotapes and microcomputers as one potential solution to this problem. To conduct this research, two pieces of equipment that could be used in vocational curricula throughout the system were chosen. They were a Computer Numerical Control (CNC) lathe used in machine shops and similar

operations and Electronic Fuel Injection Systems used in many new automobiles.

The specific objectives of the research project were:

- -To determine the feasibility of developing microcomputer simulations of equipment in vocational curricula.
- -To establish the objectives the simulations must achieve.
- -To produce two simulations utilizing videotape and microcomputers.
- -To validate the educational value of such simulations.
- -To determine the cost-effectiveness of simulations rather than equipment purchases.
- -To disseminate the research findings throughout the Community College System.

Results

Two CAI packages for use in vocational curricula were developed. The first, a program on Electronic Fuel Injection Systems for use in automotive mechanics, consists of two computer diskettes containing a tutorial, graphics simulations, and a recordkeeping system. The second, a program on Computer Numerically Controlled (CNC) equipment for use in machine shop curricula, includes a similar computer package and a videotape segment on the CNC work environment. Both packages are accompanied by an instructor's guide. The complete programs were

produced on an Apple IIe with two disk drives and a high resolution RGB monitor.

A final report and a slide/tape presentation on the project were produced. The slide/tape presentation provides a brief overview of the project activities and results.

Conclusions

Computer Assisted Instruction (CAI) using microcomputers can provide significant benefits in vocational education. These include:

1. Relief from high equipment and materials cost. The computer does not consume expensive materials and, it is cheaper to update the programs than to purchase new equipment.
2. Assistance in overcoming problems involved in group demonstrations.
3. Increased safety for students and equipment.
4. Assistance in keeping track of student progress and identifying problems on a class or individual basis through the computer's recordkeeping system.
5. Students can use CAI at the appropriate time in their learning program and can control pacing, sequence, and repetition in the program.

The initial development of CAI can be time consuming and costly. Individual colleges may need assistance in developing software

programs, but the benefits of effective simulations can be shared with other colleges.

The team approach is a useful means of organizing projects to develop computer software. Each member of the team plays an important role in insuring the success of the project.

Faculty in vocational curricula need release time both to return to industry to update their knowledge and skills and to work on the development of CAI.

Existing microcomputer hardware and software is adequate for creating simulations. However, the potential for creating more sophisticated and realistic simulations is increasing with the introduction of more advanced hardware at decreased cost, new authoring and graphics software, and interfaces for interactive video.

Although further research and development is needed, it seems clear that the microcomputer in conjunction with well developed software can play a useful role in vocational and technical education.

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Mr. Mike Pittman, NC Department of Community Colleges

Mr. Gernal Loman, Rowan Technical College

Mr. George McCloud, Catawba Valley Technical College

Ms. Kathy Munday, Edgecombe Technical College

Ms. Rosann Collins, The University of N.C. at Greensboro

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PROJECT BACKGROUND

A primary mission of the North Carolina Community College System is to provide vocational and technical training to the adult residents of the state. As the mandated deliverer of skills training, the System serves as a foundation for the State's efforts to encourage economic growth and industrial expansion. Within this context, it is essential that the 58 institutions in the Community College System remain current and responsive to the changing needs of the business and industrial environment.

Vocational training programs in all of the institutions in the System rely heavily on "hands-on" experience to prepare students for employment. This experience should provide students with exposure to state-of-the-art equipment such as that used in industry. Employers expect graduates to require minimal additional training on specific types of equipment.

PROBLEM STATEMENT

Rapid technological advances and change in business and industry have made it increasingly difficult in recent years for the insitutions in the Community College System to remain current in their vocational/technical curricula. The introduction of computerized systems in almost all areas of occupational training has resulted in the need for major upgrading of many of the System's vocational training programs. The new equipment required for such an undertaking has frequently been prohibitively expensive for many of the System's institutions. Recognition of this problem has led to increased

equipment appropriations and to major efforts to encourage business and industry to donate needed equipment to the institutions in the System.

Additional means of alleviating the problem are, however, still needed in most of the 58 institutions. In 1983-84, the equipment appropriation for the System was $13,564,314. Several of the System's smaller institutions had equipment budgets of less than $100,000 (Report on Audit, Department of Community Colleges, Term of 1983-84). For these institutions and many larger ones, major upgrading of equipment in vocational curricula remains a critical problem. The cost of one piece of CNC equipment for machining programs could consume the entire annual equipment budget for some of the smaller institutions. In addition, in this rapidly changing technological environment, equipment frequently becomes obsolete within just a few years. As a result, institutions cannot plan on a one time major investment, but are faced with the long-term problem of providing quality training programs in the most cost effective manner.

The primary purpose of this project was to research the feasibility of developing equipment simulations utilizing videotapes and microcomputers as one potential solution to this problem. Videotapes demonstrating equipment and simulations utilizing larger computers have been used extensively for training personnel in industry and the military. Computer simulations in higher education have also been useful in technical areas such as engineering, business, and agriculture; but equipment simulations for vocational education have not been readily available, and those that could be found required expensive

main-frame computers. However, the tremendously increased memory power of recent microcomputers indicated that equipment simulations might be feasible on this equipment, which is much less expensive. To conduct this research, two pieces of equipment that could be used in vocational curricula throughout the system were chosen. They were a Computer Numerical Control (CNC) lathe used in machine shops and similar operations and Electronic Fuel Injection Systems used in many new automobiles. These two areas were chosen as representative of the types of equipment that have become difficult to purchase, but which appeared to be suitable for simulation. In addition to the possibilities for providing students with exposure to state-of-the-art equipment that might not otherwise be available to them, one of the powerful features of instruction using simulations is the increased safety and economy. A student can make mistakes and learn from them without endangering the student, damaging the equipment, or wasting materials.

The hardware selected for this project included an Apple IIE microcomputer with two disk drives, an Amdek Color II high resolution RGB monitor, and an Apple graphics tablet. This equipment was chosen because of its relatively low cost, color graphics capabilities, and its widespread use in educational institutions.

OBJECTIVES

The specific objectives of the research project were:

1. To determine the feasibility of developing microcomputer simulations of equipment in vocational curricula.

2. To establish the objectives the simulations must achieve.
3. To produce two simulations utilizing videotape and microcomputers.
4. To validate the educational value of such simulations.
5. To determine the cost-effectiveness of simulations rather than equipment purchases.
6. To disseminate the research findings throughout the Community College System.

ORGANIZATION

Advisory Committee

A twelve member Advisory Committee was formed during the first three months of the project. The committee included:

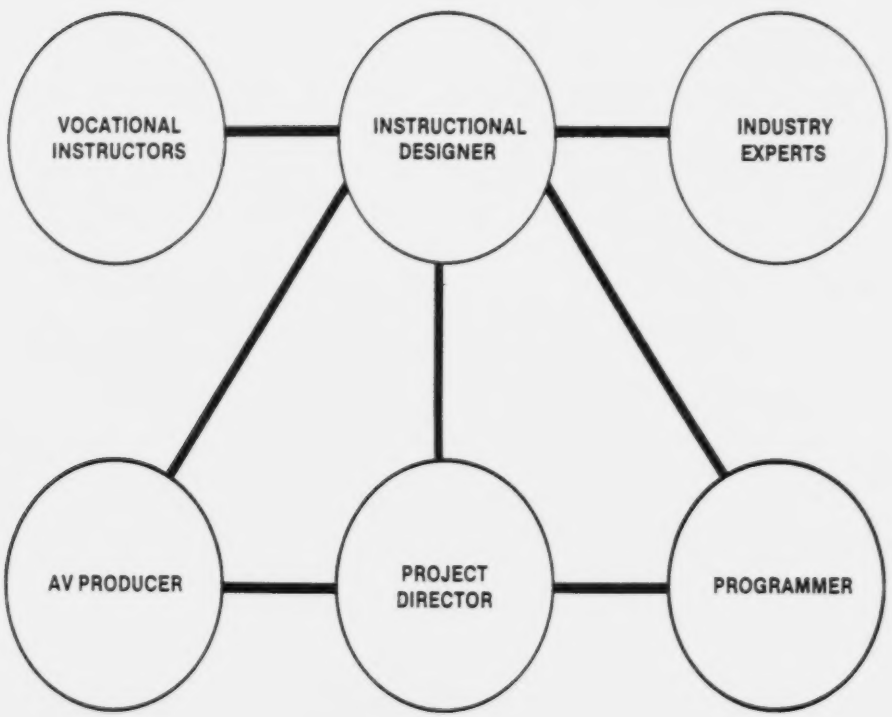
1. Representatives of the State Department of Community Colleges.
2. Vocational instructors in automotive and machine shop programs from Randolph Technical College, Rowan Technical College, and Catawba Valley Technical College.
3. An instructional designer from Edgecombe Technical College.
4. A programmer/instructional designer from the University of North Carolina at Greensboro.
5. Administrative personnel from Randolph Technical College.

The committee met quarterly to review progress on the project and to provide advice and assistance to project staff.

Team Concept

The development of the simulations required the formation of a team of individuals with expertise in a variety of areas. The team approach involved the project director, the instructional designer, the audiovisual producer, the computer programmer, vocational instructors, and content experts from industry. The team concept is illustrated in Figure 1.

Figure 1.



THE DESIGN PROCESS

After the appointment of the advisory committee and development of the design teams, the major activities of the project were related to the design process. Although the design process ostensibly involved a series of sequential activities, it was necessary in this project for many of the activities to take place simultaneously in order to meet project deadlines. The following is a brief discussion of the major activities involved in the design process for this project.

Audience Analysis

A key step in the design process is to define the target audience. This was done in part in the initial project proposal. The target audiences were broadly identified as:

1. Machine shop students enrolled in a standard four quarter machine shop curriculum in the N. C. Community College System.
2. Automotive technology students enrolled in a standard four quarter machine shop curriculum in the N. C. Community College System.

Data on students in these programs indicated that the average student is most likely to be an adult male with a high school education. Consultation with vocational instructors revealed that the majority of these students had no prior exposure to microcomputers. In addition, a

reading level analysis of entering vocational students at Randolph Technical College provided significant information for development of the tutorial units.

Job Task Analysis

With the audience demographics determined, the next step was to research the fields of machine shop technology and automotive technology. In the field of machine shop technology, the trend is toward equipment that is controlled by a microcomputer, which is referred to as Computer Numerical Control or CNC equipment. Since the mission of vocational education is to prepare students for "real world" jobs, it was necessary to conduct a "job task analysis" to determine: (1) What types of jobs are available in the area of CNC machining; and (2) What types of skills and knowledge are necessary to perform these jobs.

Because the field of CNC machining is characterized by diversity and a rapidly changing technology, the job task analysis was a time consuming process. To identify job tasks for a machinist entering a CNC environment, and to determine, therefore, what content should be included in the lesson, a number of sources from several different areas had to be consulted. These areas included:

1. Vocational instructors from technical colleges such as Randolph, Rowan, Asheville-Buncombe, and Cape Fear, in North Carolina and, the CAD/CAM Center at Greenville Tech in South Carolina.

2. Representatives of manufacturers such as Bridgeport, Mori Seiki, Cincinnati Milllcron, and Tsugami.
3. Vendor representatives from Jeffrey's Engineering and Equipment Company in Greensboro, N.C. and Fabricating and Production Machinery, Inc., in Charlotte, N.C.
4. Consultants from industries such as Ingersoll-Rand in Mocksville, N.C., Plastics Manufacturing, Inc., in Harrisburg, Virginia, and Allen-Leonard Industries in Asheboro, N.C.
5. Trade shows such as the SME Show in Charlotte, N.C., and the Automated Manufacturing 1984 Conference and Exhibition in Greenville, S.C.

Consultation with these sources produced a consensus on the CNC environment as summarized in Figure 2.

CNC JOB DESCRIPTION

	DEGREE OF MACHINE SHOP EXPER.	DEGREE OF PROGRAM -MING EXPER.	SIZE OF MACHINE SHOP
OPERATOR	LOW	LOW	LARGE
SET-UP	HIGH	MEDIUM	LARGE
SET-UP OPERATOR	HIGH	MEDIUM	MEDIUM
PROGRAMMER	MEDIUM	HIGH	LARGE
SET-UP, OPERATOR, PROGRAMMER	HIGH	HIGH	SMALL

Figure 2.

The figure illustrates the four levels of jobs found in the CNC machining field and the level of preparation necessary for each. Based on this data, it was determined that the instruction should be designed to train for the operator job role and to train generically rather than to target a specific brand of equipment. The instructional goals and objectives for the simulation should therefore be based on the skills and knowledge required for a CNC operator.

A similar but abbreviated process was followed in the field of automotive technology. Although the automotive field is also subject to changing technology, there was less ambiguity regarding job tasks or roles in the automotive field. Training for automotive mechanics focuses on two major areas, diagnostics and repair. Analysis of the tasks involved in the repair of computerized carburetion systems resulted in agreement by members of the design team that skills training in this area would not be significantly improved through the development of a computer simulation.

A similar analysis of state-of-the-art equipment in engine diagnostics was also conducted by the design team. When a detailed analysis of the tasks necessary to operate the diagnostic equipment was done, it was determined that the equipment's own software virtually leads the operator step-by-step through the operation of the equipment. Therefore, a computer simulation of this type of equipment was not seen as instructionally appropriate or cost effective.

Further consultation with automotive instructors and an outside consultant led to a consensus that the most instructionally appropriate content for a computer simulation would be in the area of basic

operations of electronic fuel injection systems. This would provide students with a simulation of processes normally hidden from the eye.

Instructional Goals

The information derived from the audience and job task analysis led to the development of a broad instructional goal and several specific goals for each of the two simulations. In the case of the CNC lesson, the audience and task analyses indicated that the lesson should include a videotape segment designed to provide a realistic introduction to the CNC environment. The following overall instructional goal for the CNC lesson was established:

-To introduce a fourth quarter machine shop student in the N. C. Community College System to some of the basic operations of CNC machining.

The instructional goal developed for the videotape segment of the CNC lesson was:

-To give students the opportunity to see an actual piece of CNC equipment in both a large and a small shop; and to show students some typical tasks of a CNC operator.

Specific instructional goals for the CNC computer simulation included the following:

-To introduce Computer Numerical Control by demonstrating its relationship to Numerical Control and Manual Machining.

-To introduce various CNC controls that are generic to CNC machines regardless of manufacturer.

-To present a number of common problems that could occur during the operation of a piece of CNC equipment and to recommend possible actions.

The instructional goal for the performance simulation game in the CNC lesson was:

-To reinforce the key concepts previously introduced.

The broad instructional goal developed for the lesson on Electronic Fuel Injection Systems was:

-To introduce to a second quarter automotive mechanics student the basis operations of computerized electronic fuel injection.

Specific instructional goals for this lesson included the following:

-To review some of the key principles of automotive fuel systems from which new principles could be linked.

-To introduce the basic operations and types of electronic fuel injection.

-To present the basic operation and elements of a computerized electronic fuel system.

Based on the audience analysis two goals were developed that were applicable to both the lesson on CNC and the lesson on Electronic Fuel Injection Systems. These included the following:

-To provide a student with no knowledge of Apple computers the information necessary to allow him or her complete control over the lesson content.

-To encourage candid reactions to the lesson by providing for anonymous comments.

Lesson Design

After the instructional goals for the lessons had been established, the content was further analyzed and verified with the content experts. The process of designing the lessons included the following steps:

1. Dividing the content into smaller instructional units.
2. Writing the learning objectives for each unit. (Appendix A).
3. Flowcharting the lesson to determine logic flow with respect to branching and testing.
4. Designing an overall evaluation plan for determining whether or not the learning objectives were met.

Since this project was primarily a feasibility study, the lesson design for both programs focused on demonstrating those unique features of a computerized delivery system as they apply to education in general and vocational education in particular.

Some of those features are:

1. Self-paced instruction
2. Immediate feedback
3. Random access
4. Animated graphics and simulation capabilities.
5. Recordkeeping.

Both lessons employ a tutorial design to present new information. This design provides the student with the opportunity to move at his or her own pace.

Lessons are broken into units which are in turn broken into segments. Each unit ends with a set of review questions, and each

question provides immediate feedback to the student. The correct answer and an explanation of the answer are given, even if the student responds correctly. This feature reinforces the concept and provides for the possibility that the student response may have been a guess.

Both lessons use a combination of linear and branching designs. All new students go through an introductory unit that explains how to run the lesson (linear). When a student has viewed the introductory unit, he or she can select specific portions of the lesson (branching). The student controls the presentation of new information through the use of the lesson menu and the specific menus for each unit. Some of the lesson segments also have menus which allow the student further choice. In addition to providing the student with control over the presentation of content, these menus aid student retention by providing the student with outlines of the material. An interesting feature of these programs is that each time a student completes a unit or segment and returns to the menu, an asterisk will appear by the choices already completed by the student. This provides the student with a means of keeping track of what he has already reviewed and of the units still to be completed.

Using the graphics tablet and inexpensive graphics software (The Graphics Magician),animated graphics were created for both the CNC and automotive programs. In the CNC program, the graphics capability of the computer is used to simulate the operation of the equipment in a troubleshooting game. Animated graphics were used in the program on Electronic Fuel Injection Systems to simulate the internal operation of the system.

Another significant feature of the computer as a delivery system is

its management capabilities. The record management system for these programs includes the following functions:

1. Records and displays student test scores.
2. Requires that students taking the lesson for the first time view the introductory unit, but makes it optional for students who have already seen it.
3. Restricts access to the program through the use of passwords and student ID numbers.
4. Provides for anonymous student feedback.

In summary, the auto lesson is primarily a branching program,with some linear functions, using a tutorial design with review questions for reinforcement. The CNC lesson utilizes the videotape format to introduce students to the job environment. The microcomputer lesson is primarily a branching program with some linear functions, using the tutorial format with review questions, and concluding with a performance simulation game for additional reinforcement.

Production

Production of the two programs involved similar activities with the exception of the production of the videotape which accompanies the CNC program. Production of the videotape involved three stages:

1. The pre-production stage, which included the writing of the script, interviewing and hiring of actors, and arranging for the shooting location.

2. The production stage, which included rehearsals and actual taping of the program.
3. The post-production stage, which included editing, mixing of background music and narration, and retaping of specific segments.

The cooperation of local industry resultd in minimal problems in the production of the videotape segment of the CNC lesson. Individuals whc provided assistance are recognized in the acknowledgements section of this report.

Work on production of the computer programs took place simultaneously with the production of the videotape. The production activities included frame by frame writing of the lessons by the instructional designer and programming or coding of the lessons by the computer programmer.

A form (Appendix B) adapted from one in the CAI Sourcebook was used by the designer to write the lessons on a frame-by-frame basis. Use of this form enabled the designer to provide the programmer with content which was already formated exactly as it was to be displayed on the computer screen. As units of instruction were completed, they were reviewed by the content specialists on the design team for accuracy and scope of content.

The material was then turned over to the programmer for coding. The programmer had to integrate the graphics, text, and recordkeeping system into a program which would be "user friendly" for students with little prior exposure to computers. The programs were written in the BASIC

programming language. As indicated in the lesson design section, an Apple graphics tablet and graphics software (The Graphics Magician by Penguin) were used to create the graphics. As sections of the program were completed, they were reviewed and revised by the instructional designer and the programmer. When the programs were completed, they were ready for field testing with a representative sample of the target audiences.

Field Testing

Field testing is designed to determine errors or problems with program logic and/or lesson content. Field testing is done under normal classroom conditions, with a representative sample of subjects. During this process, students are pretested, then complete the lesson followed by a post-test which assesses the extent of learning attributable to the lesson. Field testing of the CNC and automotive programs is described in the following sections.

A. Participants

CNC

Ten (10) machine shop students (all male) from Rowan Technical College participated in the field testing. All of these students had completed at least two quarters of a four-quarter curriculum in machine shop technology.

Electronic Fuel Injection

Thirteen (13) automotive students (12 male, 1 female) from two technical colleges in the N. C. Community College System (Randolph Technical College in Asheboro and Rowan Technical College in Salisbury) participated in the field testing. All of these students had completed at least two quarters of a four-quarter curriculum in automotive mechanics.

B. Test Design

The tests used during the field testing of the lesson included:

1. Test of Prerequisite Knowledge

CNC

Experts stated that for a student to obtain the maximum benefit from a lesson on CNC, he/she should possess the knowledge acquired from completing at least 3 quarters of a standard 4 quarter machinist program.

A test was constructed to verify this requirement by selecting 20 four-option multiple choice questions from approximately 70 questions on basic machining content and procedures.

Electronic Fuel Injection

Experts stated that prior exposure to basic automotive fuel systems was a prerequisite to understanding the lesson content.

A test was constructed to verify this requirement by selecting 20 four-option multiple choice questions from a pool of 60 questions submitted by experts on basic fuel system content and procedures.

2. The Pretest

In order to determine how much the students learned from the lesson, a pretest--post-test design was adopted.

The pretest for both programs consisted of six four-option multiple choice questions. These consisted of two separate questions per objective per unit. These same questions were not included on the post-test.

CNC

The six questions were then added to the 20 question test of basic machining content and procedures and administered to five of the students (Appendix C).

Electronic Fuel Injection

The six questions were then added to the 20 question test of general fuel system knowledge and administered to approximately half (6) of the students (Appendix D).

3. The Post-Test

The post-test was embedded in the lesson itself. It consisted of four 4-option multiple choice questions which were presented at the end of each of the three tutorial units in both programs. These questions were matched to the objectives that were stated for each of these units (Appendix E).

4. The Lesson Feedback Section

In both programs the lesson itself contains a "Feedback" section, which permits the student to make anonymous comments about the program. These comments are written to the computer's diskette file along with the post-test answers.

5. The Exit Questionnaire

An exit questionnaire was administered to each student after they had completed the lesson.

CNC

The questionnaire consisted of two parts. The first part consisted of 4 forced-choice and/or constructed response questions on Part I of the lesson, which consisted of a videotape on typical functions of a CNC operator. The second part of the questionnaire consisted of 6

forced-choice and/or constructed response questions on Part II of the lesson, which consisted of the microcomputer instruction (Appendix F).

Electronic Fuel Injection

This questionnaire was composed of a combination of 6 multiple-choice and/or constructed response questions (Appendix G).

C. Procedure

The tests just described were administered in the following manner. Both the test of prerequisite knowledge and the lesson pretest were administered at the same time, immediately before taking the lesson. As mentioned earlier, the lesson has three tutorial units, each of which is followed by review questions.

The lesson post-test was taken by the student as he or she was doing the lesson. As mentioned earlier, the lesson has three tutorial units, each of which is followed by review questions.

The exit questionnaire was administered to each student individually after completing the entire lesson.

D. Findings

1. Test Results

The following table indicates each student's individual scores on the test of prerequisite knowledge, the lesson pretest and lesson post-test, and the amount of change between the lesson pretest and the lesson post-test. It is the relationship between the lesson pretest and post-test that indicates whether the student increased his or her knowledge by taking the lesson.

TABLE 1: CNC TESTING PROFILE

Student Number	Test of Prerequisite Knowledge	Lesson Pretest	Post-Test	% Change
	-----% Correct-----			
1	70	16.6	38	+ 21.4
2	70	33.3	72	+ 38.7
3	80	--	78	--
4	55	--	78	--
5	50	50	33	- 17.0
6	75	0	72	+ 72.0
7	55	--	83	--
8	80	--	61	--
10	50	16.6	56	+ 39.4
TOTALS	65	23.33	63.4	+ 40.07

Table 2 demonstrates that learning did occur. This is evidenced by the 40% increase in scores between the lesson pretest and the post-test.

It should be noted that several instructors in the machine shop curriculum stated that three quarters of a standard four-quarter machine shop curriculum would be the minimum entry requirement for this lesson. Due to the timing of the project, the test subjects had completed only two quarters of a machine shop program.

TABLE 2: EFI TESTING PROFILE

Student Number	Prerequisite Knowledge	Lesson Pretest	Post-Test	% Change
	-----% Correct-----			
1	11	0	100	+100
2	90	66.6	89	+ 22.4
3	74	0	67	+ 67
4	42	--	78	--
5	53	--	78	--
6	68	33.3	72	+ 38.7
7	58	--	94	--
8	11	16.6	100	+ 83.4
9	37	--	56	--
10	74	--	56	--
11	79	0	88	+ 88
12	21	--	88	--
13	--*	--	83	--
TOTALS	51.6%	19.42%	80.5%	+ 61.08

*Did not take Pretest but took Lesson.

Table 2 indicates that students did in fact "learn something" from the program. This is evidenced by a 61% increase in average scores between the lesson pretest and post-test. While this increase is not statistically significant, it approached significance. Had the sample size been slightly larger, similar results would have been significant.

Knowledge of basic fuel systems does not appear to be a prerequisite for comprehension of the lesson subject matter. Regression analysis indicated that the scores of the test of prerequisite knowledge did not significantly predict post-test scores, $F(1, 11) = 1.81$, $p>.05$.

The lesson pretest does not seem to sensitize the student for the post-test, that is, students who took the pretest performed about as well as the student who did not take the pretest, $t(5) = 1.54$, $p>.05$.

2. Exit Questionnaire

Results of the Exit Quesionnaire indicate that:

(1) Students <u>at all performance levels</u> perceived the lesson as a "learning experience".

(2) Students enjoyed taking the lesson on a microcomputer. Since research into adult learning indicates that enjoyment and a sense of achievement are major

contributors to learning, these results can be considered noteworthy.

E. Revisions

Field testing of the programs suggested that certain revisions needed to be made in the programs. Revisions to both lessons were in either or both of two areas:

1. Program logic and recordkeeping.
2. The instructional design of the lesson.

Changes in the program logic centered primarily around debugging of the program; that is, a subscript error or the failure of the program to branch where it was supposed to branch. Instructional changes centered around ambiguous wording or statements in the review questions or tutorial units.

Results

1. Two CAI packages for use in vocational curricula were developed. The first, a program on Electronic Fuel Injection Systems for use in automotive mechanics, consists of two computer diskettes containing a tutorial, graphics simulations, and a recordkeeping system. The second, a program on Computer Numerically Controlled (CNC) equipment for use in machine shop curricula, includes a similar computer package and a videotape segment on the CNC work environment. Both packages are accompanied by an instructor's guide. The computer programs were produced on an Apple IIe with two disk drives and a high resolution RGB monitor.
2. A final report, a slide/tape presentation, and a pamphlet on the project were produced. The slide/tape presentation and phamplet provide a brief overview of the project activities and results.
3. Members of the design team have conducted 5 workshops for community college and public school personnel in North Carolina.

   The following is a list of those workshops:

   September 20-21, 1984--Micro 5 Conference, Winston-Salem, N.C.

   Two sessions were conducted for vocational instructors in North Carolina's public schools.

   March 28, 1985--12th Annual Learning Resources Association Conference, Greensboro, N.C.

   A session was conducted for audiovisual and instructional design personnel in the N.C. Community College System.

April 18, 1985--NCCCAEA Spring Conference, Fayetteville, N.C.

A presentation was made to Occupational Extension Directors in the N. C. Community College System.

May 8, 1985--Professional Development Institute, Randolph Technical College, Asheboro, N.C.

A presentation was made to vocational faculty in the N.C. Community College System.

June 6, 1985--Professional Development Institute, Haywood Technical College, Sylva, N.C.

A presentation was made to vocational faculty in the N.C. Community College System.

Conclusions

1. Computer Assisted Instruction (CAI) using microcomputers can provide significant benefits in vocational education. These include:
   A. Relief from high equipment and materials costs. The computer does not consume expensive materials and it is cheaper to update the programs than to purchase new equipment.
   B. Assistance in overcoming problems involved in group demonstrations.
   C. Increased safety for students and equipment.
   D. Assistance in keeping track of student progress and identifying problems on a class or individual basis through the computer's recordkeeping system.

E. Students can use CAI at the appropriate time in their learning program and can control pacing, sequence, and repetitions in the program.

2. The initial development of CAI can be time consuming and costly. Individual colleges may need assistance in developing software programs, but the benefits of effective simulations can be shared with other colleges.
3. The team approach is a useful means of organizing projects to develop computer software. Each member of the team plays an important role in insuring the success of the project.
4. Faculty in vocational curricula need release time both to return to industry to update their knowledge and skills and to work on the development of CAI.
5. Existing microcomputer hardware and software is adequate for creating simulations. However, the potential for creating more sophisticated and realistic simulations is increasing with the introduction of more advanced hardware at decreased cost, new authoring and graphics software, and interfaces for interactive video.
6. Although further research and development is needed, it seems clear that the microcomputer in conjunction with well developed software can play a useful role in vocational and technical education.

Recommendations

1. The North Carolina Department of Community Colleges should continue to encourage research and development of alternative methods of delivery, including CAI and equipment simulations on microcomputers, through funding of special projects.
2. In order to encourage ongoing development of improved instructional methodologies at the college level, funding for professional support positions such as instructional design positions should be increased.
3. Funding should be provided for faculty to return to industry to update their skills and knowledge and for release time to work on special projects.
4. The North Carolina Department of Community Colleges should provide funds for planning grants to provide colleges with expert consultants in the planning phase of a project proposal.
5. Nontraditional methods of delivery should be encouraged through examination and revision (if necessary) of existing funding formulas.
6. Funds for necessary equipment should be included in grant budgets in order to encourage smaller colleges to participate in these projects. Due to rapid change in technology and the cost of the technology, flexibility in making hardware decisions should be incorporated into the guidelines for these grants.
7. The North Carolina Department of Community Colleges should employ an expert in the field of instructional technology to provide consultative services and to work directly with the staffs of individual colleges on the development of instructional materials.

Project Critique

1. The advice of expert consultants in the fields of machining, automotive technology, and computer graphics in the planning phase of the project would have saved time and resulted in improved products. Project staff were locked in to some decisions that had been made on the basis of inadequate information. Planning grant funds awarded prior to the submittal of the final grant proposal would have alleviated this situation.
2. Lack of sufficient funds for equipment and limited flexibility in their expenditure resulted in inability to adjust to rapidly changing conditions in the availability of hardware and software.
3. Locations of content specialists with both experience with state-of-the-art equipment and time to work on the project was difficult.
4. There were a number of unanticipated problems with the field testing which limit the generalizability of the findings. Due to the timing of the project, subjects in the CNC field testing had not completed the prerequisite training prior to participating in the field testing. Due to difficulties in arranging the times and locations for testing, the sample sizes are too small for generalizing the findings. Data from field testing of one group of participants was lost due to a "bug" in the recordkeeping system of the computer program.

5. The instructional designer on the project should have been employed on a full-time basis over a shorter period rather than on a part-time basis.
6. More time should have been allowed in the time table for the project for both field testing and revision of the programs.

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APPENDIX

INTRODUCTION
TO
CNC OPERATOR

. . . .

INSTRUCTOR'S GUIDE

Gary W. Clark
Occupational Education Research Project
Randolph Technical College
November 1983 to February 1985

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SECTION ONE

INTRODUCTION

The following lesson guide, and the lesson to which it refers, is the result of a 16-month research project conducted at Randolph Technical College in Asheboro, North Carolina, with funds provided by the N. C. Department of Community Colleges through the Occupational Education Research Project.

The purpose of the project was to research the feasibility of developing educational resource materials, consisting of videotapes and microcomputer software, to provide vocational students with exposure to equipment which may be prohibitively expensive for purchase by all vocational programs within the Community College System.

This lesson is designed for vocational students who have completed approximately three quarters of a standard four-quarter machine shop program as taught in the N. C. Community College System. It assumes no prior knowledge of computer numerical control machining.

This lesson includes: The Instructor's Guide; one set of Lesson Diskettes composed of (1) Lesson Diskette and (1) Lesson/Data Diskette; and a short videotape "CNC in the Workplace".

The computerized format of this lesson offers several unique advantages. Among these are:

- -One-on-one instruction
- -Self pacing
- -Infinite review capability
- -Immediate feedback
- -Flexible schedule
- -Low cost, compared to equipment
- -Safety to both individuals and equipment.

The remainder of this guide will contain practical information on how to run and use the lesson.

SECTION TWO

LESSON OBJECTIVES

INSTRUCTIONAL GOAL: To introduce a 4th Quarter machine shop student in the N. C. Community College System to some of the basic operations of CNC machining.

PART I

VIDEOTAPE: "CNC IN THE WORKPLACE"

INSTRUCTIONAL GOAL: To give students the opportunity to see an actual piece of CNC equipment in both a large and a small shop; and to show students some typical tasks of a CNC operator.

OBJECTIVE 1: Describe CNC equipment and compare it to conventional machining equipment.

OBJECTIVE 2: Recognize job functions of a CNC operator as shown in the videotape.

PART II

COMPUTER ASSISTED INSTRUCTION

The specific unit objectives are as follows:

UNIT ONE: HOW TO USE THIS PROGRAM

INSTRUCTIONAL GOAL: To provide a student with no knowledge of Apple computers the information necessary to allow him or her complete control over the Lesson content.

OBJECTIVE: Explain the purpose and use of the following controls and/or statements:

RETURN
MENU
UNIT
SEGMENT
REPEAT
HELP

UNIT TWO: AN OVERVIEW OF NC/CNC

INSTRUCTIONAL GOAL: To introduce Computer Numerical Control by demonstrating its relationship to Numerical Control and Manual Machining.

OBJECTIVE 1: List the three basic steps of a conventional machining process.

OBJECTIVE 2: List the four basic steps of an NC machining process.

OBJECTIVE 3: List the three components of an NC machining process.

OBJECTIVE 4: Define the terms "hardwired" and "softwired".

OBJECTIVE 5: List the four significant advantages of a CNC system.

UNIT THREE: THE CNC CONTROL PANEL

INSTRUCTIONAL GOAL: To introduce various CNC controls that are generic to CNC machines regardless of manufacturer.

OBJECTIVE 1: Explain the purpose of the following four primary control functions:

ON/OFF/RESET
CYCLE START
FEED HOLD
EMERGENCY STOP

OBJECTIVE 2: Explain the purpose of the following four secondary control functions:

SPINDLE JOG
OPTIONAL STOP
COOLANT ON/OFF
DRY RUN
CHIP CONVEYOR

UNIT FOUR: TROUBLESHOOTING

INSTRUCTIONAL GOAL: To present a number of common problems that could occur during the operation of a piece of CNC equipment and to recommend possible actions.

OBJECTIVE 1: Describe the recommended actions in response to the following potential problems:

IMPERFECT FINISH
COMPUTER MALFUNCTION
CHIP CONVEYOR JAM
TOOL BREAKS
UNACCEPTABLE TOLERANCE
COOLANT EXHAUSTED
MACHINE LUBRICANT EXHAUSTED
BAR STOCK RUNS OUT

UNIT FIVE: PERFORMANCE SIMULATION GAME

INSTRUCTIONAL GOAL: To reinforce the key concepts as described in Units 2, 3 and 4.

OBJECTIVE: The student will be able to select the correct action to a troubleshooting problem from a number of possible actions, with 100% accuracy.

UNIT SIX: STUDENT FEEDBACK

INSTRUCTIONAL GOAL: To encourage candid reactions to the lesson by providing for anonymous comments.

SECTION THREE

WHAT THE INSTRUCTOR NEEDS TO KNOW TO RUN THIS LESSON

A. The Right Equipment:

One (1) Apple IIe or IIplus with 64K
One (1) Monitor (Color is best)
Two (2) Diskette Drives
One (1) Printer (optional but recommended)
One set of Lesson Diskettes, which includes:
    (1) Lesson Diskette for Drive 1, and
    (1) Lesson/Data Diskette for Drive 2
One (1) VCR and Color Monitor.

B. Getting the Computer Up and Running:

STARTUP PROCEDURES

STEP ONE.....If you are to use the APPLE IIe, be sure that the CAPS LOCK KEY, located on the lower left side of the keyboard, is in the DOWN position.

If you are using the APPLE IIplus, you do not have a CAPS LOCK KEY and therefore proceed to Step Two.

STEP TWO.....Place the diskette labeled, "LESSON DISKETTE, D1" in Drive 1.

Place the diskette labeled, "LESSON DATA/DISKETTE, D2" in Drive 2.

STEP THREE....Turn on the TV set or Monitor and let it warm up for a few moments.

STEP FOUR.....Reach behind the left rear corner of the computer case and find the power switch with your fingers.

STEP FIVE.....Turn on the computer by pressing the top of the switch.

You will hear a beep, and the POWER indicator on the computer keyboard will light up. A small red lamp on the front of DRIVE 2 will light up, and the diskette drive will make some whirring and clicking sounds.

After a few moments, the sounds will stop and the red lamp will go out.

STEP SIX.....There should now appear on the screen the following statements:

PLEASE ENTER YOUR PASSWORD?

Followed by a blinking square, called a CURSOR.

Type in the word: CRISTEN.

Then press the RETURN KEY, located on the right side of the keyboard.

NOTE: You can change the PASSWORD by following the procedure listed in SECTION THREE on PAGE 13 of this guide.

STEP SEVEN....You should now see on the screen the following information:

INSTRUCTOR'S MENU

1. Build Student File
2. Delete Old Student File
3. Look at Student File
4. Look at Feedback File
5. Reset the Feedback File
6. Print (Screen or Printer) the Test Results
7. Run NC/CNC or Quit.

(Select 1-7)

The lesson is now up and ready.

The INSTRUCTOR'S MENU allows you to set up the recordkeeping system and/or ready the program for the student.

C. Setting Up the Recordkeeping System:

If Sections A and B have been followed correctly, you should now have on the screen the INSTRUCTOR'S MENU.

The INSTRUCTOR'S MENU gives you the ability to:

1. Determine which students can do the lesson,
2. Track their progress and print out the results,
3. Receive "candid" comments on their impression of the lesson.

The following is a description of each of the menu items.

1. BUILD STUDENT FILE

This Menu selection allows you to:

a. Personalize the instruction for each student,

b. Insure that only those students authorized by you take the Lesson.

The steps in building the STUDENT FILE are as follows:

STEP ONE.....SELECT #1 FROM THE INSTRUCTOR'S MENU.
The screen will display the following message:

"NO. OF STUDENTS TAKING LESSON?"

STEP TWO.....ENTER THE NUMBER OF STUDENTS TAKING THE LESSON--PLUS ONE.

This Lesson will accept up to 24 student records.

For Example: If 24 students were to take this Lesson, you would enter 25.

If 15 students were to take this Lesson, you would enter 16.

The screen will now display the following message:

"ENTER STUDENT #1".

STEP THREE....ENTER THE NAME OF THE STUDENT AND PRESS "RETURN".

NOTE: This is an opportunity to "Personalize" the instruction by entering the name preferred by the student.

The screen will now display the following messages:

"ENTER ID NUMBER".

STEP FOUR.....ENTER A STUDENT ID NUMBER.

Student ID numbers must be assigned under the following conditions:

1. The 1st student ID must begin with 1; the second with 2 and so forth.

2. Following this number, you may add any other identification for that student, AS LONG AS YOU FOLLOW THAT NUMBER WITH A "DASH" OR "LETTER".

   For Example: 1-Bob
   2-Mike
   or
   1Clark
   2Smith
   or
   1-353
   2-161-51-4110

3. After you have entered an ID number for each student, you must add an extra DUMMY ID to close the Student File, so you should type "XCLOSE" where "X" is one more than the number of students taking the Lesson (which will be equal to the number entered in Step Two).

   For Example: With 5 Students you would type:

   6CLOSE

After the DUMMY ID has been entered, rows of numbers will briefly appear and you will be returned to the INSTRUCTOR'S MENU.

You have now set-up the recordkeeping system for this Lesson.

2. DELETE OLD STUDENT FILE

Once all the students who are going to take this Lesson have done so, and once you have either recorded their scores or printed out the results, you can clear the files for more students.

When you select #2, DELETE OLD STUDENT FILE, the screen will display the following message:

"ARE YOU SURE THIS IS WHAT YOU WISH TO DO."

"THIS WILL DESTROY THE STUDENT FILE. THIS IS OKAY IF YOU ARE STARTING WITH A NEW TEST GROUP AND HAVE RETRIEVED ALL OF THE INFORMATION YOU NEED."

"TO DELETE PRESS (D)".

"TO RETURN TO MENU WITHOUT DELETING PRESS (R)".

It is extremely important you understand that once you press (D), all the test results from the Review Questions in the Lesson ARE ERASED.

DO NOT MAKE THIS SELECTION UNLESS YOU ARE THROUGH WITH THE TEST RESULTS.

This point cannot be emphasized enough.

3. LOOK AT STUDENT FILE

This selection allows you to look at your Student Records File.

For Example:

```
1Jones      Tom      2
2Doe        John     1
3Doe        Jane     3
4           Close    0
      Press (RETURN)
```

-The first column reflects the student ID number.

-The second column is the student's name.

-The third column indicates whether that student has taken the Lesson 0 Times, 1 Time, 2 Times, or 3 Times.

-Pressing (RETURN) will return you to the INSTRUCTOR'S MENU.

4. LOOK AT FEEDBACK FILE

This Lesson gives each student the opportunity to make comments on the program.

These comments are recorded anonymously to encourage frank and honest opinions.

Pressing (RETURN) will return you to the INSTRUCTOR'S MENU.

5. RESET THE FEEDBACK FILE

This selection serves the same purpose as No. 2., DELETE OLD STUDENT FILE, and it has the same cautions.

When this selection is made, the screen will display the following messages:

"ARE YOU SURE THIS IS WHAT YOU WANT TO DO."

"TO DELETE AND RESET THE FEEDBACK FILE PRESS (D)."

"IF YOU DON'T WANT TO DELETE IT, PRESS (R) TO RETURN TO THE INSTRUCTOR'S MENU."

This selection will erase the entire FEEDBACK FILE so do not use it until you have read it.

6. PRINT (SCREEN OR PRINTER) THE TEST RESULTS

This selection allows you to view the results of the Review Questions from the Lesson.

When this selection is made, the screen will display the following message:

"ENTER THE NUMBER OF DATA DISKETTES USED."

Unless you have obtained additional Lessons, you should type 1 then press (RETURN).

The screen will display the following message:

"INSERT FIRST DATA DISKETTE" (RETURN).

As before, unless you have obtained additional Lessons, you would simply press (RETURN).

The screen will display the following messages:

"IF THIS IS NOT ALL THE DATA DISKETTES,
INSERT NEW DATA DISKETTE IN DRIVE #2,
PRESS (RETURN) WHEN READY."

If you have obtained additional Lessons, you would insert the "Lesson/Data" diskette from each of the Lessons at this point.

If you have only one set of Lesson diskettes, you would simply press (RETURN).

The screen will display the following messages:

"TO HAVE THE RESULTS PRINTED ON THE SCREEN
PRESS (S)."

"TO HAVE THE RESULTS PRINTED ON THE PRINTER,
PRESS (P)."

You would select (S) or (P) depending on whether you have a printer.

The screen or printer would then display the following chart:

			STUDENT RESPONSE							
Q	1	C	0	0	0	0	0	0	0	0
U	2	D	0	0	0	0	0	0	0	0
E	3	B	0	0	0	0	0	0	0	0
S	4	A	0	0	0	0	0	0	0	0
T	5	B	0	0	0	0	0	0	0	0
I	6	D	0	0	0	0	0	0	0	0
O	7	A	0	0	0	0	0	0	0	0
N	8	B	0	0	0	0	0	0	0	0
/	9	D	0	0	0	0	0	0	0	0
A	10	D	0	0	0	0	0	0	0	0
N	11	B	0	0	0	0	0	0	0	0
S	12	B	0	0	0	0	0	0	0	0
W	13	D	0	0	0	0	0	0	0	0
E	14	B	0	0	0	0	0	0	0	0
R	15	B	0	0	0	0	0	0	0	0

7. RUN NC/CNC OR QUIT

When this selection is made, the screen will display the following message:

"IF YOU WOULD LIKE TO START THE PROGRAM FOR THE FIRST STUDENT THEN, PRESS (S)."

"IF YOU WOULD LIKE TO QUIT, THEN PRESS (Q) AND TAKE THE DISKETTES OUT AND TURN OFF THE COMPUTER AND MONITOR."

You should select (S) if you want students to be able to do the Lesson. This may be either right after the student files have been set-up, or anytime afterwards.

You would select (Q) to QUIT the program whenever you are working from the INSTRUCTOR'S MENU.

D. How the Student Runs the Lesson:

In order for a student to do this Lesson, the Instructor must do the following:

1. Get the computer up and running. (See Section B, Getting the Computer Up and Running).

2. Set-up the Student Files (See Section C, Setting up the Recordkeeping System) if they have not been set-up previously.

3. Select No. 7 from the INSTRUCTOR'S MENU, then select (S).

The screen will display the following message:

"PLEASE ENTER YOUR NAME."

At this point, the Lesson is ready for the student(s).

Each student should be given the name and ID number assigned to them in Section B, Steps Three and Four.

After the student enters his/her name and presses (RETURN), the screen will display the following message:

"PLEASE ENTER YOUR ID NUMBER."

The student should enter the ID number assigned to him/her, then press (RETURN).

The screen will then display the title of the lesson and the student now has control of the lesson.

E. Points to Emphasize to the Student:

In order for the student to achieve maximum benefit from this computerized Lesson, the following points should be emphasized:

1. Take your time. The screen will display new information only when the student makes the selection at the bottom of each screen of information.

   This feature accommodates students of all reading levels.

2. Read the entire screen of information. Sometimes new information is presented by pressing the (RETURN) KEY; sometimes new information is presented by pressing some other key.

   Some students have a tendency not to read the entire screen and may end up in a different part of the Lesson than expected. This then confuses the students and they may have trouble getting back to where they left off.

3. Work for 100% on the Review Questions. This lesson is designed to achieve mastery of the content. If the student misses a review question or questions, he or she is encouraged to go back and read the part of the Lesson that presented the information referred to by the review question.

F. Changing the Password:

You, the Instructor, may change the Lesson password at any time for any reason.

You must first get the computer up and running, as described in Section B, Steps One through Five.

When the screen displays this message, "PLEASE ENTER YOUR PASSWORD", do the following EXACTLY AS WRITTEN:

Step 1. Press (AT THE SAME TIME): CONTROL and RESET keys on the keyboard.

Step 2. Type the following statement:

LOAD STARTUP, D1

Then press RETURN.

Step 3. Type the following statement:

4 input PW$:IFPW$<>"(YOUR NEW PASSWORD GOES HERE)" then 3

Then press RETURN.

EXAMPLE: If your new password was Horse, you type:

4 input PW$:IFPW$<>"Horse" then 3

If your new password was "Go For It", you'd type:

4 input PW$:IFPW$<>"Go For It" then 3

Step 4: Type the following statement:

SAVE STARTUP, D1

Then press RETURN.

Step 5. Type the following word:

RUN

Then press RETURN.

You should now see again the statement:

"PLEASE ENTER YOUR PASSWORD".

Type in your new password.

NOTE: The computer will try to match your password with the one you've recorded - space for space; so if your password included spaces, as in "Go For It", made sure the spaces are included.

If the screen should display this message:

SYNTAX ERROR IN 4

You should repeat Steps 1 through 5, making sure that you do not have any typing errors.

If followed exactly as written, you will now have a new password known only to you.

SECTION FOUR

WHERE TO GO WITH QUESTIONS CONCERNING THIS PROGRAM

For questions concerning the Instructional Design of this Lesson, contact:

Mr. Gary W. Clark
326 Lakeridge Drive
Kernersville, NC 27284

For all other questions, contact:

Dean, Learning Resources Center
Randolph Technical College
P. O. Box 1009
Asheboro, NC 27203

INTRODUCTION
TO
ELECTRONIC FUEL INJECTION

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INSTRUCTOR'S GUIDE

Gary W. Clark
Occupational Education Research Project
Randolph Technical College
November 1983 to February 1985

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SECTION ONE

INTRODUCTION

The following lesson guide, and the lesson to which it refers, is the result of a 16-month research project conducted at Randolph Technical College in Asheboro, North Carolina, with funds provided by the N. C. Department of Community Colleges through the Occupational Education Research Project.

The purpose of the project was to research the feasibility of developing educational resource materials, consisting of videotapes and microcomputer software, to provide vocational students with exposure to equipment which may be prohibitvely expensive for purchase by all vocational programs within the Community College System.

This lesson is designed for vocational students who have had an introduction to basic fuel system as commonly taught in the N. C. Community College System.

This lesson includes: The Instructor's Guide; and one set of lesson diskettes composed of (1) Lesson Diskette and (1) Lesson/Data Diskette.

The computerized format of this lesson offers several unique advantages. Among these are:

-One-on-one instruction
-Self pacing
-Infinite review capability
-Immediate feedback
-Flexible schedule
-Low cost, compared to equipment
-Safety to both individuals and equipment.

The remainder of this guide will contain practical information on how to run and use the lesson.

SECTION TWO

LESSON OBJECTIVES

INSTRUCTIONAL GOAL: To introduce to a second quarter automotive mechanics student the basic operations of computerized electronic fuel injection.

UNIT ONE: HOW TO USE THIS PROGRAM

INSTRUCTIONAL GOAL: To provide a student with no knowledge of Apple computers the information necessary to allow him or her complete control over the Lesson content.

OBJECTIVE: Explain the purpose and use of the following controls and/or statements:

RETURN
MENU
UNIT
SEGMENT
REPEAT
HELP

UNIT TWO: FOUNDATIONS OF FUEL INJECTION

INSTRUCTIONAL GOAL: To review some of the key principles of automotive fuel systems from which new principles could be linked.

OBJECTIVE 1: Name the four ingredients necessary for combustion.

OBJECTIVE 2: Describe the three factors that can affect combustion.

OBJECTIVE 3: Describe the Venturi Principle as it relates to carburetion.

UNIT THREE: BASIC FUEL INJECTION SYSTEMS

INSTRUCTIONAL GOAL: To introduce the basic operations and types of electronic fuel injection.

OBJECTIVE 1: Describe the Bosch Continuous Injection System and the major reason for its success.

OBJECTIVE 2: Describe the two principle locations of modern fuel injection systems.

OBJECTIVE 3: Describe the two principle methods of modern fuel injection.

UNIT FOUR: COMPUTERIZED ELECTRONIC FUEL INJECTION (CEFI)

INSTRUCTIONAL GOAL: To present the basic operation and elements of a computerized electronic fuel system.

OBJECTIVE 1: Describe the function of the computer in a computerized electronic fuel injection system.

OBJECTIVE 2: List the four common CEFI components and their functions.

OBJECTIVE 3. List the seven common CEFI sensors and their functions.

UNIT FIVE: STUDENT FEEDBACK

INSTRUCTIONAL GOAL: To encourage candid reactions to the lesson by providing for anonymous comments.

SECTION THREE

WHAT THE INSTRUCTOR NEEDS TO KNOW TO RUN THIS LESSON

A. The Right Equipment:

One (1) Apple IIe or IIplus with 64K
One (1) Monitor (Color is best)
Two (2) Diskette Drives
One (1) Printer (optional but recommended)
One set of Lesson Diskettes, which includes:
    (1) Lesson Diskette for Drive 1, and
    (1) Lesson/Data Diskette for Drive 2
One (1) VCR and Color Monitor.

B. Getting the Computer Up and Running:

STARTUP PROCEDURES

STEP ONE.....If you are to use the APPLE IIe, be sure that the CAPS LOCK KEY, located on the lower left side of the keyboard, is in the DOWN position.

If you are using the APPLE IIplus, you do not have a CAPS LOCK KEY and therefore proceed to Step Two.

STEP TWO.....Place the diskette labeled, "LESSON DISKETTE, D1" in Drive 1.

Place the diskette labeled, "LESSON DATA/DISKETTE, D2" in Drive 2.

STEP THREE....Turn on the TV set or Monitor and let it warm up for a few moments.

STEP FOUR.....Reach behind the left rear corner of the computer case and find the power switch with your fingers.

STEP FIVE.....Turn on the computer by pressing the top of the switch.

You will hear a beep, and the POWER indicator on the computer keyboard will light up. A small red lamp on the front of DRIVE 2 will light up, and the diskette drive will make some whirring and clicking sounds.

After a few moments, the sounds will stop and the red lamp will go out.

STEP SIX.....There should now appear on the screen the following statements:

PLEASE ENTER YOUR PASSWORD?

Followed by a blinking square, called a CURSOR.

Type in the word: CRISTEN.

Then press the RETURN KEY, located on the right side of the keyboard.

NOTE: You can change the PASSWORD by following the procedure listed in SECTION THREE on PAGE 12 of this guide.

STEP SEVEN....You should now see on the screen the following information:

INSTRUCTOR'S MENU

1. Build Student File
2. Delete Old Student File
3. Look at Student File
4. Look at Feedback File
5. Reset the Feedback File
6. Print (Screen or Printer) the Test Results.
7. Run Auto or Quit.

(Select 1-7)

The lesson is now up and ready.

The INSTRUCTOR'S MENU allows you to set up the recordkeeping system and/or ready the program for the student.

C. Setting Up the Recordkeeping System:

If Sections A and B have been followed correctly, you should now have on the screen the INSTRUCTOR'S MENU.

The INSTRUCTOR'S MENU gives you the ability to:

1. Determine which students can do the lesson,
2. Track their progress and print out the results,
3. Receive "candid" comments on their impression of the lesson.

The following is a description of each of the menu items.

1. BUILD STUDENT FILE

This Menu selection allows you to:

a. Personalize the instruction for each student,

b. Insure that only those students authorized by you take the Lesson.

The steps in building the STUDENT FILE are as follows:

STEP ONE.....SELECT #1 FROM THE INSTRUCTOR'S MENU.
The screen will display the following message:

"NO. OF STUDENTS TAKING LESSON?"

STEP TWO.....ENTER THE NUMBER OF STUDENTS TAKING THE LESSON--PLUS ONE.

This Lesson will accept up to 24 student records.

For Example: If 24 students were to take this Lesson, you would enter 25.

If 15 students were to take this Lesson, you would enter 16.

The screen will now display the following message:

"ENTER STUDENT #1".

STEP THREE....ENTER THE NAME OF THE STUDENT AND PRESS "RETURN".

NOTE: This is an opportunity to "Personalize" the instruction by entering the name preferred by the student.

The screen will now display the following messages:

"ENTER ID NUMBER".

STEP FOUR.....ENTER A STUDENT ID NUMBER.

Student ID numbers must be assigned under the following conditions:

1. The 1st student ID must begin with 1; the second with 2 and so forth.

2. Following this number, you may add any other identification for that student, AS LONG AS YOU FOLLOW THAT NUMBER WITH A "DASH" OR "LETTER".

   For Example: 1-Bob
   2-Mike
   or
   1Clark
   2Smith
   or
   1-353
   2-161-51-4110

3. After you have entered an ID number for each student, you must add an extra DUMMY ID to close the Student File, so you should type "XCLOSE" where "X" is one more than the number of students taking the Lesson (which will be equal to the number entered in Step Two).

   For Example: With 5 Students you would type:

   6CLOSE

After the DUMMY ID has been entered, rows of numbers will briefly appear and you will be returned to the INSTRUCTOR'S MENU.

You have now set-up the recordkeeping system for this Lesson.

2. DELETE OLD STUDENT FILE

Once all the students who are going to take this Lesson have done so, and once you have either recorded their scores or printed out the results, you can clear the files for more students.

When you select #2, DELETE OLD STUDENT FILE, the screen will display the following message:

"ARE YOU SURE THIS IS WHAT YOU WISH TO DO."

"THIS WILL DESTROY THE STUDENT FILE. THIS IS OKAY IF YOU ARE STARTING WITH A NEW TEST GROUP AND HAVE RETRIEVED ALL OF THE INFORMATION YOU NEED."

"TO DELETE PRESS (D)".

"TO RETURN TO MENU WITHOUT DELETING PRESS (R)".

It is extremely important you understand that once you press (D), all the test results from the Review Questions in the Lesson ARE ERASED.

DO NOT MAKE THIS SELECTION UNLESS YOU ARE THROUGH WITH THE TEST RESULTS.

This point cannot be emphasized enough.

3. LOOK AT STUDENT FILE

This selection allows you to look at your Student Records File.

For Example:

```
1Jones      Tom      2
2Doe        John     1
3Doe        Jane     3
4           Close    0
      Press (RETURN)
```

-The first column reflects the student ID number.

-The second column is the student's name.

-The third column indicates whether that student has taken the Lesson 0 Times, 1 Time, 2 Times, or 3 Times.

-Pressing (RETURN) will return you to the INSTRUCTOR'S MENU.

4. LOOK AT FEEDBACK FILE

This Lesson gives each student the opportunity to make comments on the program.

These comments are recorded anonymously to encourage frank and honest opinions.

Pressing (RETURN) will return you to the INSTRUCTOR'S MENU.

5. RESET THE FEEDBACK FILE

This selection serves the same purpose as No. 2., DELETE OLD STUDENT FILE, and it has the same cautions.

When this selection is made, the screen will display the following messages:

"ARE YOU SURE THIS IS WHAT YOU WANT TO DO."

"TO DELETE AND RESET THE FEEDBACK FILE PRESS (D)."

"IF YOU DON'T WANT TO DELETE IT, PRESS (R) TO RETURN TO THE INSTRUCTOR'S MENU."

This selection will erase the entire FEEDBACK FILE so do not use it until you have read it.

6. PRINT (SCREEN OR PRINTER) THE TEST RESULTS

This selection allows you to view the results of the Review Questions from the Lesson.

When this selection is made, the screen will display the following message:

"ENTER THE NUMBER OF DATA DISKETTES USED."

Unless you have obtained additional Lessons, you should type 1 then press (RETURN).

The screen will display the following message:

"INSERT FIRST DATA DISKETTE" (RETURN).

As before, unless you have obtained additional Lessons, you would simply press (RETURN).

The screen will display the following messages:

"IF THIS IS NOT ALL THE DATA DISKETTES,
INSERT NEW DATA DISKETTE IN DRIVE #2.
PRESS (RETURN) WHEN READY."

If you have obtained additional Lessons, you would insert the "Lesson/Data" diskette from each of the Lessons at this point.

If you have only one set of Lesson diskettes, you would simply press (RETURN).

The screen will display the following messages:

"TO HAVE THE RESULTS PRINTED ON THE SCREEN
PRESS (S)."

"TO HAVE THE RESULTS PRINTED ON THE PRINTER,
PRESS (P)."

You would select (S) or (P) depending on whether you have a printer.

The screen or printer would then display the following chart:

			STUDENT RESPONSE							
Q	1	C	0	0	0	0	0	0	0	0
U	2	D	0	0	0	0	0	0	0	0
E	3	B	0	0	0	0	0	0	0	0
S	4	A	0	0	0	0	0	0	0	0
T	5	B	0	0	0	0	0	0	0	0
I	6	D	0	0	0	0	0	0	0	0
O	7	A	0	0	0	0	0	0	0	0
N	8	B	0	0	0	0	0	0	0	0
/	9	D	0	0	0	0	0	0	0	0
A	10	D	0	0	0	0	0	0	0	0
N	11	B	0	0	0	0	0	0	0	0
S	12	B	0	0	0	0	0	0	0	0
W	13	D	0	0	0	0	0	0	0	0
E	14	B	0	0	0	0	0	0	0	0
R	15	B	0	0	0	0	0	0	0	0

7. RUN AUTO OR QUIT

When this selection is made, the screen will display the following message:

"IF YOU WOULD LIKE TO START THE PROGRAM FOR THE FIRST STUDENT THEN, PRESS (S)."

"IF YOU WOULD LIKE TO QUIT, THEN PRESS (Q) AND TAKE THE DISKETTES OUT AND TURN OFF THE COMPUTER AND MONITOR."

You should select (S) if you want students to be able to do the Lesson. This may be either right after the student files have been set-up, or anytime afterwards.

You would select (Q) to QUIT the program whenever you are working from the INSTRUCTOR'S MENU.

D. How the Student Runs the Lesson:

In order for a student to do this Lesson, the Instructor must do the following:

1. Get the computer up and running. (See Section B, Getting the Computer Up and Running).

2. Set-up the Student Files (See Section C, Setting up the Recordkeeping System) if they have not been set-up previously.

3. Select No. 7 from the INSTRUCTOR'S MENU, then select (S).

The screen will display the following message:

"PLEASE ENTER YOUR NAME."

At this point, the Lesson is ready for the student(s).

Each student should be given the name and ID number assigned to them in Section B, Steps Three and Four.

After the student enters his/her name and presses (RETURN), the screen will display the following message:

"PLEASE ENTER YOUR ID NUMBER."

The student should enter the ID number assigned to him/her, then press (RETURN).

The screen will then display the title of the lesson and the student now has control of the lesson.

E. Points to Emphasize to the Student:

In order for the student to achieve maximum benefit from this computerized Lesson, the following points should be emphasized:

1. Take your time. The screen will display new information only when the student makes the selection at the bottom of each screen of information.

   This feature accommodates students of all reading levels.

2. Read the entire screen of information. Sometimes new information is presented by pressing the (RETURN) KEY; sometimes new information is presented by pressing some other key.

   Some students have a tendency not to read the entire screen and may end up in a different part of the Lesson than expected. This then confuses the students and they may have trouble getting back to where they left off.

3. Work for 100% on the Review Questions. This lesson is designed to achieve mastery of the content. If the student misses a review question or questions, he or she is encouraged to go back and read the part of the Lesson that presented the information referred to by the review question.

F. Changing the Password:

You, the Instructor, may change the Lesson password at any time for any reason.

You must first get the computer up and running, as described in Section B, Steps One through Five.

When the screen displays this message, "PLEASE ENTER YOUR PASSWORD", do the following EXACTLY AS WRITTEN:

Step 1. Press (AT THE SAME TIME): CONTROL and RESET keys on the keyboard.

Step 2. Type the following statement:

LOAD STARTUP, D1

Then press RETURN.

Step 3. Type the following statement:

4 input PW$:IFPW$<>"(YOUR NEW PASSWORD GOES HERE)" then 3

Then press RETURN.

EXAMPLE: If your new password was Horse, you type:

4 input PW$:IFPW$<>"Horse" then 3

If your new password was "Go For It", you'd type:

4 input PW$:IFPW$<>"Go For It" then 3

Step 4: Type the following statement:

SAVE STARTUP, D1

Then press RETURN.

Step 5. Type the following word:

RUN

Then press RETURN.

You should now see again the statement:

"PLEASE ENTER YOUR PASSWORD".

Type in your new password.

NOTE: The computer will try to match your password with the one you've recorded - space for space; so if your password included spaces, as in "Go For It", made sure the spaces are included.

If the screen should display this message:

SYNTAX ERROR IN 4

You should repeat Steps 1 through 5, making sure that you do not have any typing errors.

If followed exactly as written, you will now have a new password known only to you.

SECTION FOUR

WHERE TO GO WITH QUESTIONS CONCERNING THIS PROGRAM

For questions concerning the Instructional Design of this Lesson, contact:

Mr. Gary W. Clark
326 Lakeridge Drive
Kernersville, NC 27284

For all other questions, contact:

Dean, Learning Resources Center
Randolph Technical College
P. O. Box 1009
Asheboro, NC 27203

CAI LESSON CODING FORM

AUTHOR:_____ DATE:_____

LESSON:_____ SEGMENT:_____

TOPIC:_____ FRAME NUMBER:_____

REVISION NUMBER:_____ VALIDATION DATA:_____

LINE #	OP CODE	LESSON CONTENT (5 10 15 20 25 30 35 40)	
*LAB	T:		1
	T:		2
	T:	CALCULATE THE MEAN OF THE	3
	T:	FOLLOWING TEST SCORES.	4
	T:		5
	T:	SALLY 86 JAMIE 94	6
	T:	BILLY 68 JANE 76	7
	T:	JOHNNY 85 BETTY 65	8
	T:	GREG 72 MARY 82	9
	T:	SHIRLEY 91 PHYLLIS 88	10
	T:	DONNY 85 GARY 79	11
	T:		12
	T:	ANSWER:_____	13
	T:		14
	T:		15
	T:		16

CIRCLE THE LETTER YOU CONSIDER TO BE THE BEST ANSWER TO THE QUESTION.

IF YOU DO NOT KNOW THE ANSWER, LEAVE IT BLANK.

1. A particular material is indicated on a drawing to be C.R.S. The material most likely used is

   A. chromium refined steel
   B. copper rod sections
   C. carbon ribbon steel
   D. cold rolled steel

2. A piece of metal is measured by a standard micrometer which reads 0.184 inches. The thimble scale reading in divisions is therefore

   A. 4
   B. 9
   C. 5
   D. 24

3. A drawing has a dimension of $3" \pm \begin{matrix}.003" \\ .004"\end{matrix}$. This means

   A. the job need not be carefully machined
   B. the tolerance is .008"
   C. the same as a dimension $\begin{matrix}(3.003" \\ (2.996"\end{matrix}$
   D. the tolerance is .006"

4. The majority of radius gages are made

   A. in a unit with feeler gages
   B. in a unit with a thread gage
   C. with an adjustable radius
   D. with a convex and concave radius of the same size on one blade

5. In order to preven breaking a drill

   A. use a lighter feed as the hole becomes deeper
   B. use a lower speed as hole becomes deeper
   C. allow cuttings to collect in the hole
   D. don't lubricate except for cast iron

6. In cutting a spur gear some of the operations in proper order are

   A. place gear on mandrel; mount arbor in milling machine; place cutter on arbor; center head with cutter; mount work in dividing head
   B. cut teeth; take trial cut; mount work in dividing head; mount arbor in machine
   C. mount arbor in machine; take trial cut; mount work in dividing head; set work to the cutter
   D. place gear on mandrel; mount arbor in machine; set work to the cutter; take trial cut

7. Assume that a keyway is to be laid out on a shaft. The tools in one of the following groups would be some of those required

   A. square, dividers, prick punch, hacksaw
   B. V blocks, surface gage, divider, prick punch
   C. dividers, cane chisel, hammer, keyway rule
   D. V blocks, keyway rule, hammer, protractor

8. When brass is being drilled, compared to drilling mild steel, for proper operation

   A. the speed for steel should be greater than for brass
   B. the speed for brass is never greater than 1,000 r.p.m.
   C. the speed for an 1 inch drill should be twice that for a 2 inch drill in either case
   D. the speed for brass is closely 3 times that for steel

9. In a double cut file the two sets of teeth are

   A. cut at different angles to the center line
   B. cut at 72 and 80 degrees to the center line
   C. cut at 40 and 43 degrees to the center line
   D. cut at the same angle to the center line

10. The use of fluids in metal cutting operations will <u>not</u> generally

    A. cool the tool
    B. cool the work
    C. flush away the chips
    D. increase the pressure of the chip on the tool

11. With regard to surface finishes produced in machine operations, it can be said

    A. a lapped surface is smoother than a ground surface
    B. a milled surface is smoother than a ground surface
    C. a lapped surface is rougher than a milled surface
    D. a lapped surface is smoother than a Johansson block

12. Twist drills are commonly specified as follows:

    A. by numbers only (for example, 1 to 80)
    B. by letters only (for example, A to Z)
    C. by numbers, letters and fractional sizes
    D. by fractional sizes only (for example, 3/64)

13. If a screw cutting lathe has a swing of sixteen (16) inches, it commonly means

    A. that it can take work up to eight (8) inches in diameter
    B. work up to sixteen (16) inches in diameter can be machined
    C. that the distance between centers can be made up to sixteen (16) inches
    D. that the distance between the headstock center and the bed is sixteen (16) inches

14. The knurling tool as commonly used in lathe work

A. is only of one grade of coarseness
B. should not be removed from the work when returning to the starting point for a second impression
C. operates from the lead screw as in thread cutting
D. should operate only at the highest headstock spindle speed

15. Climb cutting on a milling machine

A. means that the cut is taken on the upward movement of the cutter
B. should always be used where scale is on the piece to be milled
C. means that the work moves with the direction of the cutter
D. means that only one speed of feed can be used regardless of the material

16. A sine bar as commonly used by a machinist

A. is made of soft metal
B. is used for laying out angles on work
C. is a lever used in place of a drift pin
D. is used for tapping down work in a shaper vise

17. The term "tolerance" as commonly used by a machinist means

A. the amount of variation permitted in the size of a part
B. the maximum permissible dimension of a part
C. the difference in the dimensions of mating parts
D. the size that a "GO" gage would fit

18. The index head or dividing head as used on a milling machine

A. is to move the work a given amount on its axis
B. changes the depth of the cut
C. is only used for cutting spur gears
D. changes the amount of the feed

19. Which one of the following is <u>not</u> a cause for a drill making a hold that is too large?

A. equal lengths of the cutting edges
B. the point angles unequal
C. unequal lengths of the cutting edges
D. play in the spindle

20. The correct procedure when filing a flat piece held in a vise is

A. to make a faster stroke for harder material
B. to relieve the pressure on the back stroke
C. not to keep the file pressed firmly all during the forward stroke
D. to lubricate the piece after each twenty strokes

* 21. Softwired controls differ from Hardwired controls in that Softwired controls:

A. Can be easily modified
B. Are difficult to upgrade in the field
C. Utilize fixed circuit connections
D. Have no part in CNC.

* 22. Which of these capabilities allows a part program to be written from an existing part?

A. Digitizing

B. Diagnostics

C. Interaction Communications

D. Stored Programs.

* 23. Using which of the following controls will require that all program data in the system be reentered before continuing the machining process?

A. Dry Run

B. On/Off Reset

C. Emergency Stop

D. Optional Stop

* 24. Which of the following controls is used primarily during setup?

A. Emergency Stop

B. Chip Conveyor Control

C. Spindle Jog

D. Coolant On/Off

* 25. If the chip conveyor jams, which action would you take first?

A. Press Optional Stop

B. Turn Off Chip Conveyor

C Press Emergency Stop

D. Call Supervisor

* 26. The purpose of a CNC Machine's Lubricant is to:

A. Act as a base ingredient when mixed with the coolant.

B. Eliminate expansion of the Part during machining.

C. Reduce wear and tear within the micro processor.

D. Reduce friction within the CNC.

NOTE: Those questions with an asterisk beside the numeral are the pre-test questions.

CIRCLE THE LETTER YOU CONSIDER TO BE THE BEST ANSWER TO THE QUESTION.

IF YOU DO NOT KNOW THE ANSWER, LEAVE IT BLANK.

*1. The "ideal" air to fuel ratio is often complicated by which of the following real world problems:

a. Gasoline, Size of Engine, Type of Carburetion
b. Altitude, Atmosphere, Weather Conditions
c. Driver, type and make of vehicle
d. Air to Fuel Mixture, Pressure, Burning Time.

2. On chokes with an adjustable cover, the reference mark for making the initial setting is called the:

a. position mark
b. fast-idle mark
c. cold-engine mark
d. index mark.

3. The only service the evaporative control system requires is periodic replacement of the:

a. canister
b. canister filter
c. charcoal
d. fuel lines.

*4. The Venturi Principle states when air is forced through a passage that is smaller than its current one:

a. it will be too thin to be combined with gasoline
b. it creates a vacuum
c. it increases its velocity
d. it produced a turbocharged affect.

5. When a mechanic tests the PCV system, the tester indicates REPAIR. This means that:

a. there is a vacuum in the crankcase
b. there is a pressure in the crankcase
c. there is an air leak into the crankcase
d. none of the above.

6. A rotten-egg smell with BB-size particles coming out the tail pipe could be caused by:

a. worn carburetor jets
b. a defective fuel pump
c. a defective catalytic converter
d. a defective EGR system.

7. After a cold start, the choke should open within:

   a. 1½ minutes
   b. 3½ minutes
   c. 5½ minutes
   d. 10 minutes

8. Feedback controlled carburetors operate in either of two modes:

   a. feedback and feed forward
   b. bypass and non-bypass
   c. open loop and closed loop
   d. suction throttling and non-suction throttling.

*9. The Bosch CIS system contains an Electronic Fuel Supply pump which:

   a. determines how much fuel is required for combustion
   b. keeps fuel under high pressure to the injector valves
   c. keeps a constant supply of fuel in the float bowl
   d. supplies gasoline to the carburetor when requested by the E.C.U.

10. The feedback carburetor:

   a. feeds back fuel to the engine when needed
   b. does not need an idle system
   c. adjusts the air-fuel mixture ratio as information is fed back to it by an electronic control unit
   d. controls the power and choke systems electronically.

11. The power enrichment system adds fuel to the:

   a. low speed circuit
   b. accelerator pump circuit
   c. main metering circuit
   d. float circuit.

12. The purpose of the hot-idle compensator is to:

   a. supply additional air for idling when the engine is hot
   b. slow down engine speed
   c. prevent a hot engine from running when the ignition is shut off
   d. increase idle speed while the engine is cold.

13. To prevent vapor lock, many cars are equipped with:

   a. an evaporative emission control system
   b. a vapor return line
   c. a combination fuel pump
   d. a mechanical fuel pump.

14. The automatic choke is closed by:

   a. vacuum
   b. a bimetal spring
   c. atmospheric pressure
   d. accelerator linkage.

15. The purpose of the PCV system is to:

a. remove exhaust gases from the crankcase
b. remove blowby gases from the crankcase
c. improve engine cooling
d. none of the above.

*16. Modern Fuel Injection systems are classified according to:

a. make and manufacturer
b. gasoline or diesel
c. where and how air/fuel is mixed
d. type of control unit.

17. The anti-dieseling solenoid plunger is extended when the:

a. ignition key is on
b. ignition key is off
c. choke is on
d. choke is off.

18. The four-barrel carburetor is essentially:

a. four 1-barrel carburetors in one assembly
b. two 2-barrel carburetors, each with two primary barrels
c. two 2-barrel carburetors, each with one primary and one secondary barrel
d. two 2-barrel carburetors, each with two secondary barrels.

19. When the engine is hot and running at 600 rpm, the gasoline is supplied by the:

a. idle system
b. low-speed system
c. choke system
d. main metering system.

20. The idle-stop solenoid prevents dieseling by:

a. completely closing the throttle valve when the ignition switch is turned off
b. preventing excessively high idle speed
c. stopping engine idle when the engine gets hot
d. all of the above.

*21. Which of the following factors were in a large part responsible for the mass production of fuel injection in family cars:

a. foreign imports
b. emission control regulations
c. the recession of the mid 70's
d. down sizing of the American automobile.

22. The APT carburetor has:

a. an extra throttle valve
b. an extra barrel
c. an extra metering rod adjusted at the factory
d. all of the above.

23. The operating mechanism of the vacuum-operated metering rod includes either a:

a. vacuum piston or pump
b. diaphragm or pump
c. vacuum piston or diaphragm
d. none of the above.

* 24. Which of the following contributed to the decline of the popularity of the traditional carbureted fuel systems:

a. complex modern designs
b. shortage of parts
c. popularity of diesel engines
d. poor fuel economy.

25. The fast-idle cam position is controlled by:

a. high manifold vacuum
b. a spring on the throttle valve
c. an arm on the choke shaft
d. the air-fuel mixture.

26. Gasohol is a mixture of unleaded gasoline and

a. 10 percent ethyl alcohol
b. 90 percent ethyl alcohol
c. 50 percent ethyl alcohol
d. 10 percent liquefied petroleum gas.

NOTE: Those questions with the asterisk beside the numeral are the pre-test questions.

Program Review Questions
-Automotive-

1. Combustion occurs when which of the following elements affect the air to fuel ratio:

   a. pressure
   b. vacuum
   c. time
   d. velocity

2. What is the "ideal" air to fuel ratio?

   a. 12.5 to 1
   b. 14.7 to 1
   c. 15 to 1
   d. 2 to 1

3. When the air and fuel pressure is too low, it is said to be:

   a. Rich
   b. Lean
   c. Full
   d. Ideal

4. Spark timing should be advanced under which of the following conditions?

   a. Cold timperatures
   b. High altitudes
   c. Trailer towing
   d. Acceleration

5. The increased velocity of air passing throuth the venturi produces:

   a. flooding in the float bowl.
   b. a lean air/fuel mixture.
   c. a low pressure area.
   d. a whistling sound.

6. Air flows through the venturi as a result of vacuum created by:

   a. the piston.
   b. the vacuum pump.
   c. incoming air.
   d. the venturi.

7. The venturi resembles most closely:

   a. a beer bottle.
   b. an hour glass.
   c. a funnel.
   d. a hose.

8. the Bosch Continuous Injection System proved quite successful because it utilized:

   a. solid state electronics.
   b. injector valves.
   c. high octane gasoline
   d. vacuum tubes.

9. An innovative design aspect of the Bosch CIS system was activating the injector valves:

   a. one at a time.
   b. all at once.
   c. in groups.
   d. every other one.

10. The amount of fuel dispersed by the injector valves in the Bosch system is determined by:

   a. fuel pressure.
   b. length of time the injector valves are open.
   c. the manner in which the injector valves are open.
   d. the amount of air present.

11. The Throttle-Body replaces the:

   a. fuel pump.
   b. electronic computer.
   c. power module.
   d. carburetor.

12. Both Throttle-Body and Port Injection systems can be:

   a. pulse-timed or controlled.
   b. continuous or controlled.
   c. pulse-timed of continuous.
   d. none of the above.

13. In Port Injection, fuel is combined with air in:

a. the conbustion chambers.
b. the intake manifold.
c. the carburetor.
d. the exhaust manifold.

14. The Electronic Control Module utilizes input from which of the following:

a. Driver.
b. Sensors.
c. Operating conditions.
d. all of the above.

15. The efficiency and fuel economy of computerized fuel injection depends on:

a. when the injection valves open.
b. how far the injection valves open.
c. how long the injection valves open.
d. all of the above.

16. Which of the following is responsible for analyzing exhaust for leaness and richness:

a. Oxygen Sensor.
b. Exhaust Gas Recirculating Valve Sensor.
c. Barometric Pressure Sensor.
d. Vacuum Sensor.

17. Which of the following is responsible for supplying the ECU with the necessary information required to properly time the pulses with the injectors in Timed-Port injection?

a. Throttle Position Sensor.
b. Vacuum Sensor.
c. Crankshaft Position Sensor.
d. None of the above.

18. Which of the following are the main components in Computerized Electronic Fuel Injection systems?

a. Fuel, Fuel Pump, Throttle Position Sensor, Vacuum Sensor.
b. Oxygen Sensor, Fuel Pressure Regulator Valve, Vacuum Sensor.
c. Fuel, Fuel Pump, Fuel Pressure Regulator Valve, Fuel Injectors.
d. Crankshaft Position Sensor, Vacuum Sensor, Oxygen Sensors.

PROGRAM REVIEW QUESTIONS
-CNC-

1. Which of the following are the proper sequences for NC machining?

   a. Blueprint, Part Program Manuscript, Set-up.
   b. Blueprint, Tool & Work Positioning, Coding, Set-up.
   c. Blueprint, Part Program Manuscript, Coding, Set-up.
   d. Blueprint, Tool & Work Positioning, Set-up.

2. Which of the following is not a component of the NC machining process?

   a. Part Program
   b. Control Unit
   c. Machine Tool
   c. Head Stock

3. Hardwired controls differ from softwired controls in that they:

   a. can be altered eaisly.
   b. utilize fixed circuit connections.
   c. are controlled by a computer.
   d. are controlled by what is known as an "Executive Program".

4. Which of the following could be considered the most significant capability of CNC machines?

   a. Interactive Communications.
   b. Stored Programs.
   c. Diagnostics.
   d. Digitizing.

5. Which of the following CNC capabilities is responsible for the efficiency of CNC machines?

   a. Interactive Communications.
   b. Stored Programs.
   c. Diagnostics.
   d. Digitizing.

6. CNC controls can be classified as:

   a. Machine or computer.
   b. Primary or Secondary.
   c. Function.
   d. All of the above.

7. Which of the following controls align the spindle position with the axes and zero point?

   a. On/Off/Reset.
   b. Spindle Jog.
   c. Cycle Start.
   d. None of the above.

8. Indicate which of the following controls are Primary or Secondary by typing (P) for Primary or (S) for Secondary next to the corresponding letter below:

   a. Cycle Start
   b. Optional Stop
   c. Coolant On/Off
   d. Feed Hold
   e. Emergency Stop

9. Which of the following controls allow you to interrupt the machining cycle without losing machine tool synchronization ?

   a. Dry Run
   b. Emergency Stop
   c. Optional Stop
   d. Feed Hold

11. The Emergency Stop should be used:

   a. only as a last resort.
   b. whenever the urge hits you.
   c. to prevent eventual damage to the machine.
   d. anytime there is an "immediate" danger to yourself or the machine.

12. If a tool breaks, and the break does not present an "immediate" danger, you should first:

   a. call supervisor right away.
   b. press Feed Hold/Cycle Interrupt.
   c. press Emergency Stop.
   d. wait till current cycle ends.

13. Cutting metals such as Cold Rolled Steel without coolant could result in:

   a. an imperfect finish.
   b. an in acurate cut.
   c. a chip conveyor jam.
   d. internal gears locking up.

14. The sound of an "Alarm Bell" signifies:

a. coolant needs to be replaced.
b. lunch.
c. a tool has broken.
d. machine lubricant is out.

15. If an imperfection is suspected during machining cycle, the operator should halt the cycle by pressing the Emergency Stop.

a. Yes
b. No

16. A good rule of thumb is to use "extreme" caution whenever working inside a CNC during the machine cycle.

a. True
b. False

EXIT QUESTIONNAIRE
CNC PROGRAM

PART I

The following questions refer to the videotape only:

1. Did the videotape help you understand what a CNC machine does?

   YES NO

2. Do you feel the videotape helped you understand the job of the CNC operator?

   YES NO

3. Do you think watching videotapes like this is a good way to learn?

   YES NO

4. Please make any further comments you would like to make:

PART II

These questions refer to the computer program:

1. Did you have any problems with how to run the program?

   If so, what were they?

2. Did you have any problems with the Lessons themselves?

   Were they: Too Simple?
   Too Hard?
   Confusing?

3. Was the Lesson Material wrong anywhere?

   If so, where?

4. Were the review questions: Too Hard?
   Too Easy?
   About Right?

5. Do you feel you learned anything from this program?

6. What is your overall reaction to the program? Did you like using it?